MISSOURI RIVER DESIGN STUDY

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REPORT NO. 3

LABORATORY INVESTIGATION OF SIOUX CITY BOAT MARINA ENTRANCE

MEAD HYDRAULIC LABORATORY
MEAD, NEBRASKA

U. S. ARMY ENGINEER DISTRICT, OMAHA
U. S. ARMY ENGINEER DISTRICT, KANSAS CITY
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This report presents the results of a model study of the entrance to a proposed small boat marina on the Missouri River at Sioux City, IA. The study was conducted by personnel of the Channel Stabilization Section and Hydraulics and Sediment Section of the Omaha District, Corps of Engineers, and under the general supervision of the Missouri River Division.

Small boat marinas located along the banks of an alluvial stream are continually plagued by the formation of sediment deposits within the basin or near the basin entrance. Experience has shown that most marinas require dredging at regular intervals in order to maintain sufficient operating depths. The constant exchange of water between the stream and the basin carries with it a fine suspended material which deposits in the still pool formed by the marina basin. Since there is no current to remove this material, the basin soon becomes depleted of all available storage.

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DEPARTMENT OF THE ARMY
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LABORATORY INVESTIGATION
OF
SIOUX CITY BOAT MARINA ENTRANCE

Conducted at
MEAD HYDRAULIC LABORATORY
MEAD, NEBRASKA

U. S. ARMY ENGINEER DISTRICT, OMAHA, NEBR.
U. S. ARMY ENGINEER DISTRICT, KANSAS CITY, MISSOURI
MISSOURI RIVER DIVISION, OMAHA, NEBRASKA
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LABORATORY INVESTIGATION OF SIOUX CITY BOAT MARINA ENTRANCE

INTRODUCTION

This report presents the results of a model study of the entrance to a proposed small boat marina on the Missouri River at Sioux City, Iowa. The study was conducted by personnel of the Channel Stabilization Section and the Hydraulics and Sediment Section of the Omaha District, Corps of Engineers, and under the general supervision of the Missouri River Division.

PURPOSE OF STUDY

Small boat marinas located along the banks of an alluvial stream are continually plagued by the formation of sediment deposits within the basin or near the basin entrance. Experience has shown that most marinas require dredging at regular intervals in order to maintain sufficient operating depths. The constant exchange of water between the stream and the basin carries with it a fine suspended material which deposits in the still pool formed by the marina basin. Since there is no current to remove this material, the basin soon becomes depleted of all available storage.

This model study was conducted to:

(1) Determine the best location of the marina entrance relative to the existing river training structures and bank protection works, so that deposition near the entrance would be kept to a minimum;

(2) For a given location of entrance, determine means which might reduce the rate of deposition in and around the basin entrance.

DESCRIPTION OF STUDY REACH

The proposed boat marina is to be located on the left bank of the Missouri River upstream of the Highway 73-77 bridge near Sioux City, Iowa. It will be located between existing dikes 807.91 and 807.6 in a reach of the river where the main component of the flow is crossing from the left to the right bank. The map on Plate 1 shows the location of the proposed marina. The basin will be formed by isolating the area between these two existing dikes from the river by a structure parallel to the river alignment. An opening in this structure will serve as the entrance to the marina. Existing conditions indicate that sediment has a tendency to accumulate downstream of dike 807.91, and that a siltation problem would very likely result in the vicinity of the proposed marina entrance.

TEST PROCEDURE

A short reach of the river in the vicinity of the marina was constructed in the laboratory. Most of the tests were conducted using a discharge representing 30,000 c.f.s. in the Missouri River; however, a few tests simulated large flood flows. Since it was important to determine locations of scour and deposition, a 1/60 undistorted scale was used in the model. Due to space limitations, only the left half of the river channel, the basin entrance, and a small portion of the berthing area were constructed on the model.

DESCRIPTION OF TESTS

The first group of tests utilized a trail dike parallel to the general river channel alignment as the breakwater between the marina and the river. This was assumed to be set back 50' landward from the ends of the existing structures in the prototype. At one-foot intervals provisions were made for openings to represent possible locations for an entrance to the marina.

All of the tests with simple openings in the trail dike exhibited a tendency for one component of the flow to intersect the downstream edge of the opening and be diverted into the basin. (Refer to Fig. 1, Plate 2) This was much more apparent for openings located near dike 807.91 and decreased as they were moved downstream. This component of flow into the basin carried a suspended load with it which was deposited in the basin. The exchange of water between the river and the basin set up a definite circulation pattern within the basin which is also shown in Fig. 1, Plate 2.

One test was run with two openings into the basin, one near the upstream end and one near the downstream end. This proved to be very unsatisfactory, as water would enter the upstream entrance, drop its suspended load, and continue on out the lower entrance.

Various arrangements of spur dikes placed normal to the trail dike were also studied. These did appear to divert the flow away from the entrance; however, the area behind and downstream from the spur dikes usually filled in with sediment. This resulted in undesirable deposits near the marina entrance. A single spur dike located downstream of the entrance, upstream of the entrance, and a combination of the two were studied. None of the above combinations appeared to improve the overall entrance characteristics enough to justify their use.

A breakwater or trail dike placed at an angle with the channel alignment was studied in the second group of tests. The dike intersected structure 807.91 250 feet from the riverward end and proceeded 1,300 feet downstream where it ended on the channel line. Tests very similar to those discussed in the previous paragraphs were made with this arrangement. (Refer to Fig. 2, Plate 2)

Entrances installed in the angled structure acted very similar to those where the breakwater was parallel with the flow. It became apparent that moving the upstream end of the trail dike landward from the channel line simply results in creating a deadwater area which fills with sediment. The lower end of the angled structure may, however, aid in diverting the flow toward the opposite bank farther downstream.

One variation from the angled trail dike study was to leave the entire structure intact and construct an opening around the downstream end. This required leaving a narrow channel parallel to the dike and on the landward side as an entrance to the basin. The test indicated that a bar would develop immediately downstream from the end of the structure, completely blocking passage into the basin area. (See Fig. 3, Plate 2)

The third group of tests centered around a plan to utilize the turbulence or eddy developed off the end of spur dikes to maintain a self-scouring entrance. The Hydrotechnical Research Institute in Bucharest, Romania, issued a report[1/] in which they state that they have been successful in developing systems of dikes which will decrease the amount of siltation around boat basin entrances.

Using information from this report as a guide, the system shown on Plates 3 and 4 was developed. It involves three component parts, all of which are necessary and work together to provide the desired result. The first component involves a spur dike on the upstream side of the entrance. This structure serves to divert the flow away from the entrance and results in an eddy immediately downstream of the structure. The second component involves the dike at the downstream side of the entrance. This dike intersects this eddy, sending one portion into the main channel and the remainder toward the basin proper. The third component is an intersecting baffle projecting from the downstream dike. This baffle intersects the current attempting to enter the basin and diverts it upstream. Near the upstream spur dike, the eddy is intersected by the flow passing around the spur dike. The eddy is then carried out into the channel and a complete cycle is set in motion. Figures 1 and 2 on Plate 5 illustrate how the system operated in the model.

Our tests showed that this arrangement gave very good results, with little or no material transported into the basin proper. It was found that the upstream dike must be at an angle sufficiently to create a disturbance or eddy, and in some cases it may require the use of an underwater sloping sill to encourage this. When this underwater sill was tested in the Sioux City model, very little benefit was noted. However, there may be locations where the flow characteristics may be such that the additional disturbances created by an underwater sill may be desirable.

1/ "Silting Up of Port Basins" by Eng A. Spataru, Hydrotechnical Research Institute, Bucharest, Romania.

This type of entrance was studied at a location 12.2 feet downstream of dike 807.91 in the model (730 feet in prototype). For the Sioux City location, it is considered advisable to keep the entrance at least 500 feet downstream from this dike.

Several of the above systems were subjected to unusually high stages and discharges. Due to physical limitations, it was not always possible to reproduce the correct stage in the model. However, these tests did indicate that a considerable amount of deposition would be likely to occur in the basin area should a high discharge occur, regardless of the shape of the basin or location of the entrance.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that a system of dikes as shown on Plate 3 & 4 be used to reduce the amount of deposition in and near the Sioux City marina entrance. The model tests showed that the location of the baffle projecting from the downstream dike is very critical and depends upon the size and shape of the eddy pattern developed by the upstream dike. The dimensions shown on the Plate 4 were found to be satisfactory in the model and should be used as a guide for construction of the marina.

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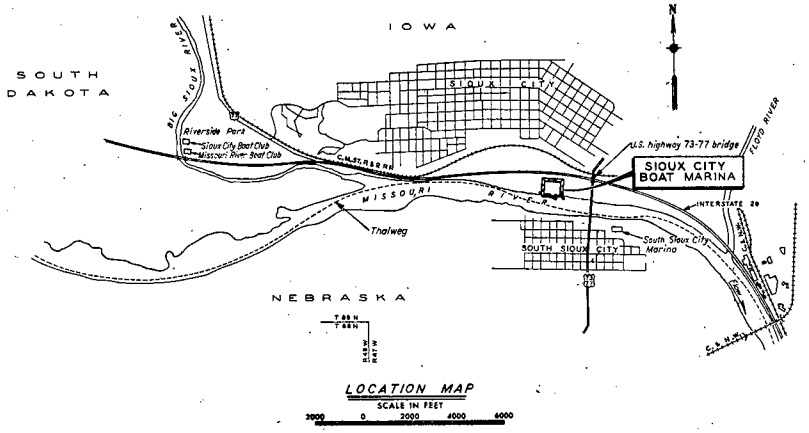
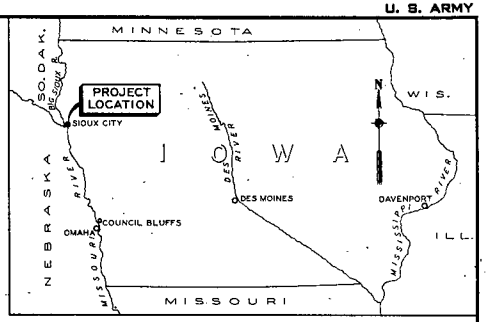


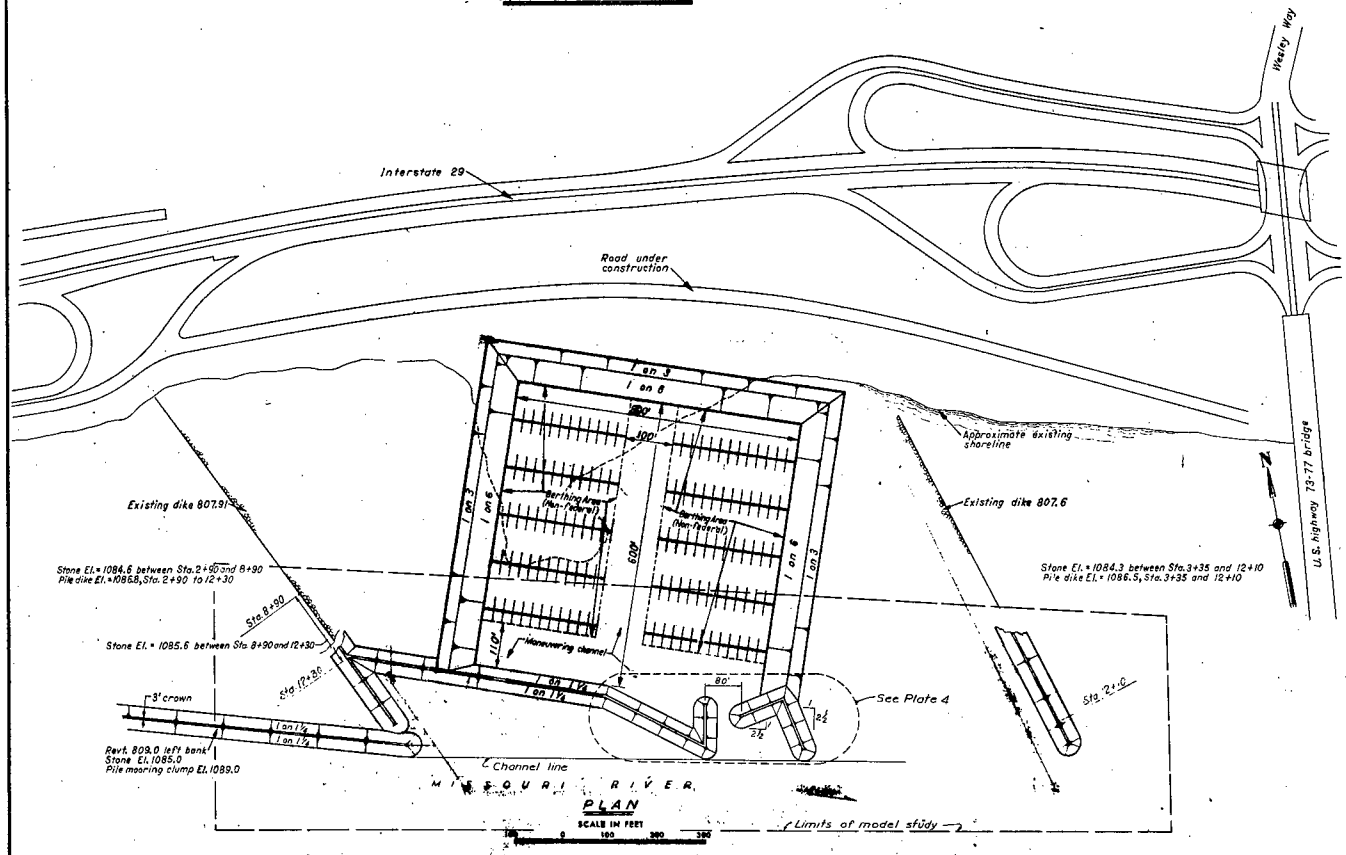
LOCATION MAP

SCALE IN FEET

2000 0 2000 4000 6000



VICINITY MAP



PLAN

SCALE IN FEET

100 0 100 200 300

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PLATE 1

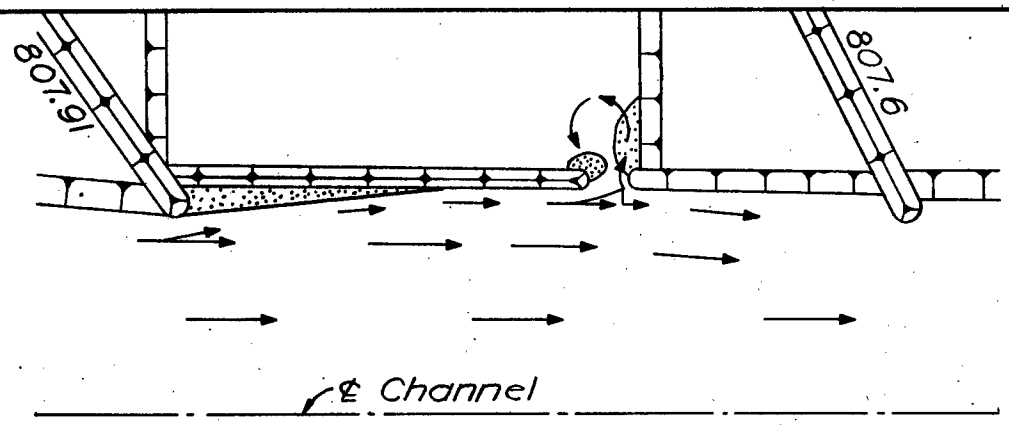

FIG. 1 - Basin formed by trail dike parallel to channel alignment. Entrance formed by opening in dike.

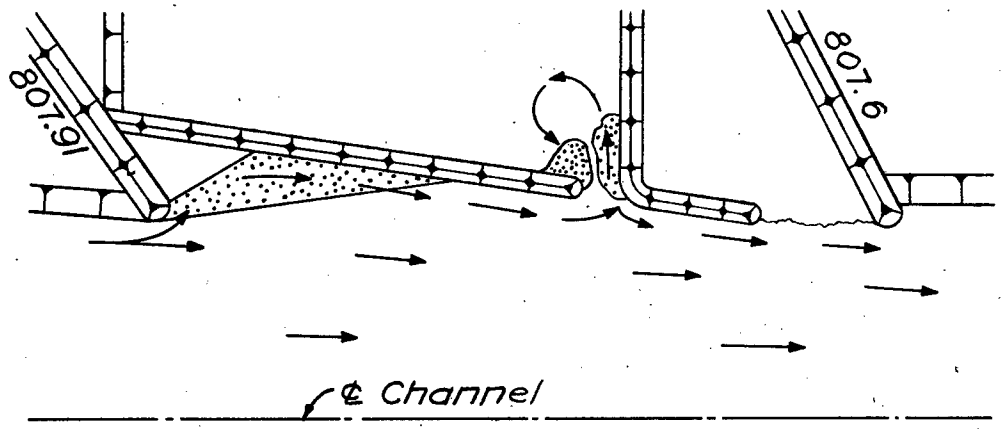

FIG. 2 - Basin formed by trail dike placed at an angle to channel alignment. Entrance formed by opening in dike.

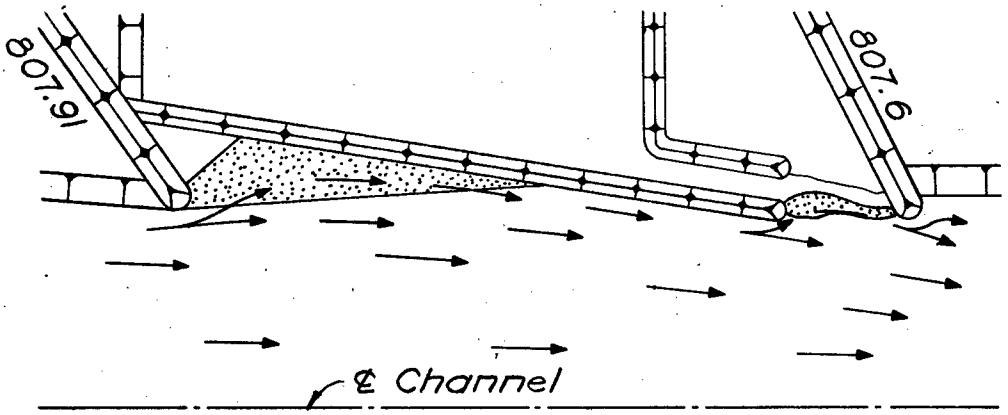

FIG. 3 - Basin formed by trail dike placed at an angle to channel alignment. Entrance formed by opening around end of dike.

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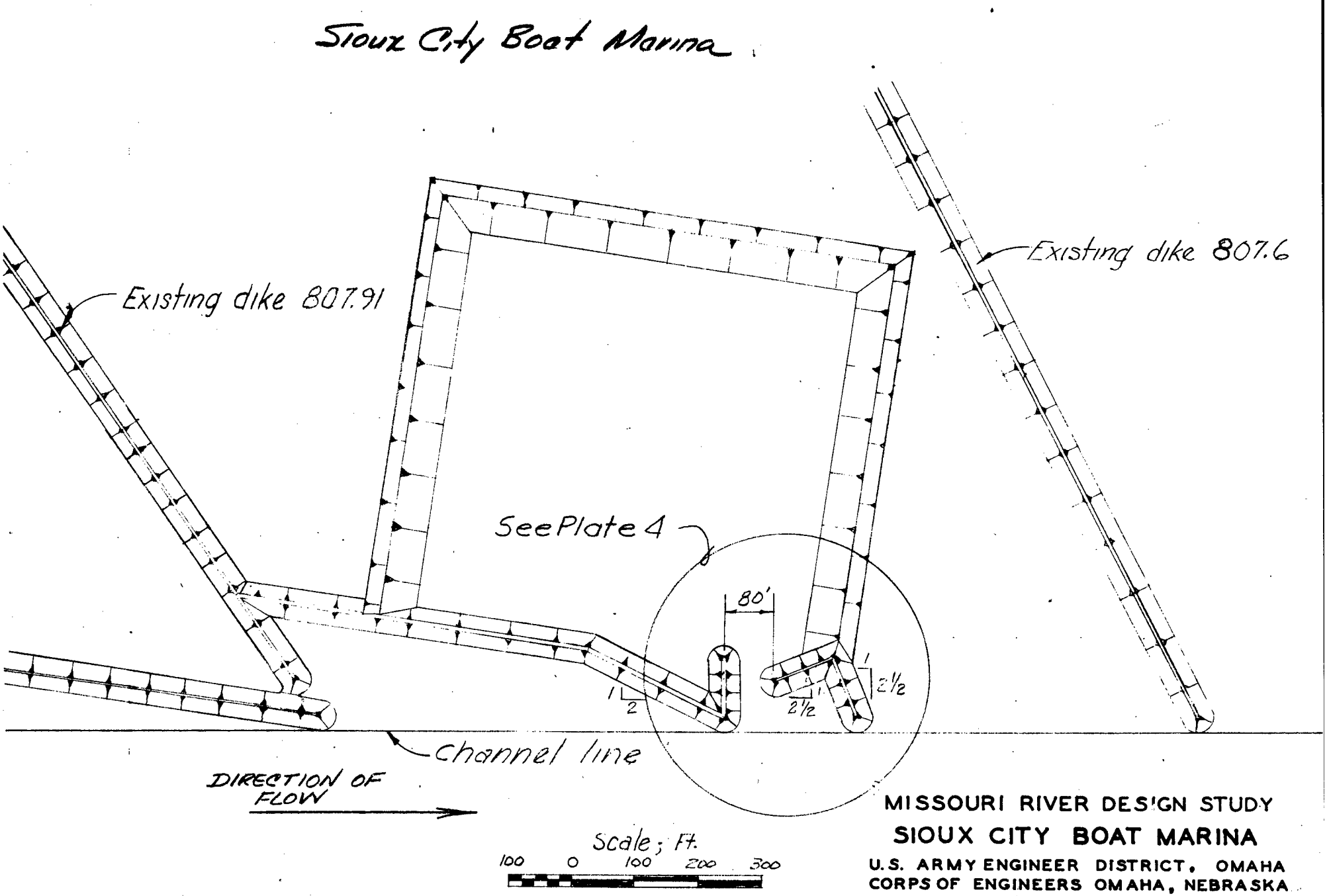

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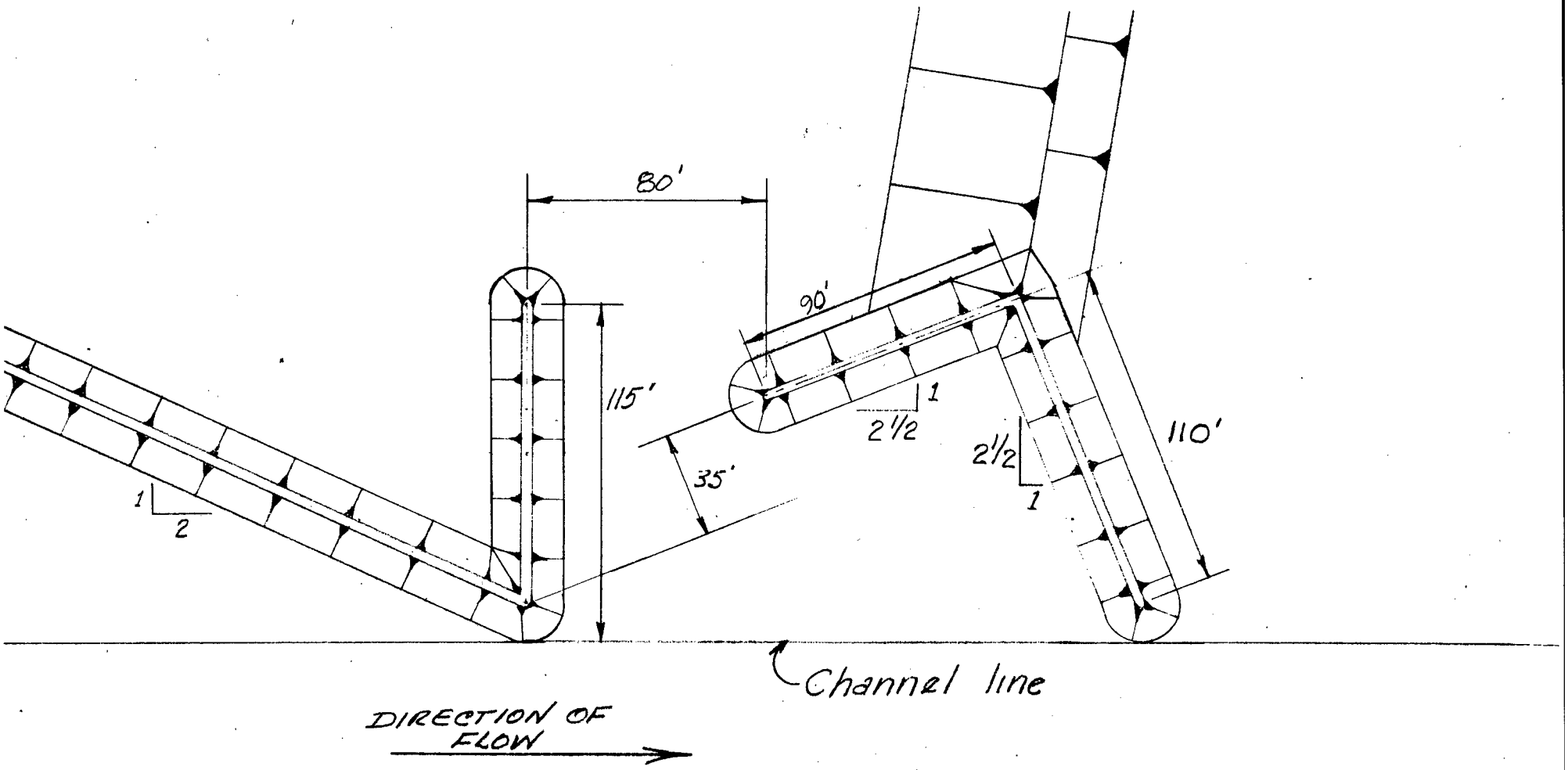
PLATE 3



SCALE IN FEET

50 0 50

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PLATE 4

FIG. 1 - Photo shows recommended opening without presence of intersecting baffle. Note large area of deposition in entrance.

FIG. 2 - Recommended opening with intersecting baffle. Deposition in entrance is eliminated with no movement in basin area.